these resolutions are of but small importance to us in England, as they relate to such well understood and generally agreed to subjects as the necessity of providing substantial concrete foundations underneath paved roadways, a form of construction which has been generally adopted in England for the last quarter of a century, and to methods of drainage and similar matters equally understood by us.

On a matter, however, of common interest, that is, the substitution of tar or bituminous binding material in place of the water hitherto used to consolidate and hold together the road material, and which is conveniently dealt with under the French name "*Goudronnage*," the congress practically gave a unanimous answer. This was to the effect that if *goudronnage* be properly carried out; if the tar or similar material be chosen with reasonable care to avoid matter soluble in water, such as ammoniacal liquor remaining mixed in the tar so that it can be subsequently washed out by the rain or dried out in the form of crystals which might afterwards form an irritating dust; if the tar be put on in the correct quantity, and this quantity the smallest required to hold the individual stones of the road metal firmly in position, so that they never roll or move in relation to one another, and their upper surfaces are allowed to wear themselves bare of tar, it is not a difficult matter to obtain, at quite a moderate expense, a waterproof road which will not do any damage to vegetation, which will be practically dustless if it be swept at reasonable intervals from horse droppings or dust blown upon it from the adjoining land, and which need not be slippery, either to horse or to automobile traffic, whether the surface be wet or dry.

It appears certain also that by so dealing with the roadways their wear can be so greatly reduced that the annual cost of upkeep of roads so treated will be considerably less than the cost of the existing water-bound roads, of which so much of the material is lost by being blown away as dust in summer or washed away as mud in winter.

There can be no doubt that all engineers, English and Continental, are at one on this important question, and this in spite of the fact that many paragraphs, obviously inspired by those who wish to recommend other binding materials, were widely circulated in the journals during the progress of the congress. It had been roundly asserted that tar was a palliative, but that on the whole its defects were greater than its advantages. Those who were present at the congress know that this is an incorrect statement; that such damage as has occurred to trees and vegetation, or inconvenience to passengers, such as irritation of the eyes and throat, which followed on the early applications of tar to the French roads during the Grand Prix race, was due to well understood causes, that is to say, to the use of crude tar and its application to a road surface which had already broken up, both of which faults the congress unanimously condemned.

It may be here remarked that owing to the cautiousness, and hence the reticence, of some of the most important of our road authorities, the true position of England, which now possesses the greatest lengths of carefully waterproofed roads of any country in the world, was not put forward so much as might have been the case.

It was interesting to converse with American engineers, who, on account of the importance of road development in America, are studying this question very closely, and to hear from them how much more they could learn by visiting our English roads than anywhere in France, at any rate near the capital. French engineers, although they have practised *goudronnage* to a considerable extent, have not been careful enough in excluding the ammoniacal liquor, and in many cases have put on the tar irregularly and in far too great a quantity; wherever this is the case softening in hot weather and slipping in wet weather is likely to follow.

Before the congress of last week closed the question of the next congress was talked of, and it appears likely to be held in Brussels in about two years' time.

As regards that section of the congress relating to the influence of the vehicles themselves on the road, some of the papers were very valuable; but curiously enough the French, who above all other nations were the first to appreciate the great advantages of large wheel diameter, in their draft resolutions fixing the maximum weights to be carried per unit width of wheel left out the important factor of the influence of wheel diameter, though, luckily, owing to the influence of the English-speaking delegates, it is probable this factor will be reinstated in the form in which it exists in our own very well-considered regulations issued by the Local Government Board.

SCIENCE AT THE UNIVERSITIES.

THE proceedings at the academic ceremonies held in Oxford on October 8 to celebrate the fiftieth anniversary of the opening of the University Museum, described in our issue of last week, and especially the address delivered by the Vice-Chancellor, Dr. Warren, President of Magdalen College, may well serve as an encouragement to the older men of science who have for many years been unwearying in their insistence that science should occupy a high place of honour among the branches of learning cultivated at the universities. The statement of progress at Oxford during the last fifty years, which the Vice-Chancellor and Dr. Vernon Harcourt presented, should act as an inspiration to the present distinguished staff of scientific teachers to whom the world is looking to develop in connection with their university a centre of scientific activity unsurpassed at any ancient or modern seat of learning.

How complete the change of attitude towards science has been at Oxford may be gathered from the description of the state of things immediately preceding the building of the museum which the Vice-Chancellor gave at the beginning of his address:—

> Science was not a stranger to Oxford before the first stone of the museum was laid, but her existence was somewhat precarious and her progress intermittent. The period just before the establishment of the museum was, like the night before the dawn, a somewhat dark age. It is, I believe, recognised in physiological science that the history of the embryo repeats the history of the race. It appeared to be so with science at that time. She was then in the condition of the cave dwellers among primitive men. At any rate, she lived underground. Her teachers, like those of the early Church, wandered about in "caves and dens of the earth." There was a cellar under the Ashmolean where science was taught. If I remember right, my old friend, whom I much wish we could have seen here to-day, Prof. Story-Maskelyne, was both taught, and instructed himself, in that underground chamber. There was another cellar, or series of cellars, in Balliol College, where my wife's father, Prof. Brodie, used to pursue chemistry; but it would not be fair to represent this as the whole history of science in Oxford even at that time. Dr. Daubeny at my own college, Magdalen, and Dean Buckland, as he afterwards was, at Christ Church, had already done pioneer work. To-day things are very different. Natural science has now, as you will see this afternoon, a palace with many chambers and apartments, well and, it may be said in some instances, beautifully equipped. That is not everything, and will not alone

secure success. Much of the very best work, as we all know, in science has been done in very inferior quarters and with very poor appliances.

Dr. Warren's personal acquaintance with the work of the museum, extending as it does over about two-thirds of the fifty years of its existence, his well-known strong interest in natural science, and his full appreciation of the paramount influence the scientific method exerts on every form of human activity, make his sketch of the work accomplished by the great men of science who have been associated with the museum especially valuable. He said:—

I have seen the museum, then, and its work, growing and advancing for something over thirty years. I can recall the individual characteristics and work of the eminent professors who have served it in its different departments during this period, the brilliant zoological series of Rolleston, Moseley, Lankester, and Weldon, and the brilliant geological series of Philips, Prestwich, and Green. I can remember the introduction of physiology and the epoch-making advent of Sir John Burdon-Sanderson. All along the line there has been continuous, steady, and healthy growth. I do not know how the number of students or the departments of the museum now would compare with that of the numbers when I was an undergraduate. I will take one simple test. I find that in 1872, the year I came to Oxford, the number of names in the natural science honours list is ten. The number of names last term in the corresponding list is seventy-four, seven times as many. When I was an undergraduate the Oxford Medical School was a shadow of a mighty name. The medical student was a *rara avis*. My impression is that there was one, or at the most two, a year at Balliol when I was there, and in the whole University I should doubt whether there were a dozen. In the strict sense there were hardly any. That is to say, there was scarcely a student studying medicine in any of its branches within the University. Now all that is changed. We have been singularly fortunate in our series of medical professors, Sir Henry Acland, Sir John Burdon-Sanderson, Dr. Osler. It would be difficult to show a more brilliant trio or a trio more suited to complement and supplement each other's labours. I have always held, and I think that experience has justified the belief, that a strong medical school would be for the advantage of pure science in Oxford. Out of practical schools, if properly administered, research work grows, just as again research gives ever new life to practical studies. I think the same is true of practical studies like forestry, which we have recently introduced; agriculture, a still later introduction; and engineering, which I am rejoiced to think is just going to commence its work here. It will be seen, then, that science has made an immense advance in Oxford.

We welcome this advance, and we look forward hopefully to the future in store for science in the University of Oxford. We acknowledge frankly and gratefully that the serious Oxford student realises fully the beneficial influence which the earnest pursuit of the methods of scientific inquiry in a university has upon other studies. We know that many Oxford professors and students of other subjects acknowledge that the adoption of the methods perfected by men of science to problems in their particular domains have led to unprecedented results. But it is still true that the average Oxford man leaves his Alma Mater profoundly ignorant of the scientific method, and with a scarcely veiled contempt for natural knowledge; and it is the ordinary university man, who remains undistinguished from the academic point of view, who eventually exerts a predominating influence in Parliament, and in county and municipal affairs.

In his address the Vice-Chancellor dealt with these facts, and his wise words foster the hope that steps will be taken to ensure that no man ignorant of the fundamental principles of science shall leave his university with any sort of academic diploma.

With all this activity in its own field, natural science does not really affect, as it should, the minds of the rank and file of our able young students here. It is not brought home to them; they do not appreciate or understand it. They either still retain some of that old prejudice and contempt which regarded science at schools as an *extra* or a *fad*, or else they are indifferent to it. Some few years ago I remember Prof. Lankester complaining that our statesmen and public men generally reared in our public schools and at the old universities were insensible of, indifferent to, the claims of science. I think that while he spoke strongly, as he often does, I think he also spoke as he not seldom does, even when he speaks strongly, with reason. This ought not to be the case. It is the scientific attitude and frame of mind, the scientific outlook on the world, as a part of general culture, which is, I think, what is wanted in education, and particularly in Oxford education, to-day. Oxford has many great intellectual traditions. Some of them are less strong than they were, but they are still potent. The old scholastic tradition, partly theological, partly philosophical, partly logical, is still potent with us. Our predominating school, even if it is now only *prima inter pares*, is the philosophical school of *Literae Humaniores*. It affects insensibly and indirectly even those who never read for it. It is an admirable tradition. So again is the more literary tradition of our classical scholarship. I hope that these traditions will always be maintained. I think they do to some extent affect the scientific student here. I should like to see them affect him more than they do, and I believe that I should carry many of the leading men of science with me in that desire. But what I should also like to see is the classical and the literary, the philosophical and the theological student, more affected by science. I should like to see science an element in our general education both in our schools and in the universities, and we are told, and I believe it is true, that if we wish to have it in the schools, we must insist on having it in the university. It is not so much that I think the small amount of actual knowledge which would be acquired by the individual student would be of great value, but I think it would conduce to the creation of this general atmosphere which I desire to see created.

Fortunately it is becoming recognised increasingly that the object to be aimed at in every sphere and stage of education is the inculcation of the scientific spirit, a patient training in the methods of science, which leads a person, whatever the problem with which he is confronted, courageously to look facts in the face, and after a broad survey of the conditions so far as available processes of inquiry make possible, humbly to endeavour to trace the causes of the effects which have been accurately and honestly recorded. Science has before now been taught, not only in schools, but in the universities themselves, in such a manner as to obscure rather than elucidate the attitude of the true man of science, but the Vice-Chancellor made it clear that this danger is fully appreciated at Oxford. As he remarked:—

The real lessons of science do not, I think, consist in knowledge of facts. . . . They consist in the recognition of the importance of truth, of absolute scrupulous accuracy in matters great or small; that nothing happens without a cause and without a consequence; that matter, however mutable it may be, is indestructible; that the same elements, or many of them, as are found in our earth may be found, for instance, in the sun, and probably pervade the universe; that energy in the same way is imperishable; the general scientific conception of force, of atoms, of gravitation, of resistance, of mass, of proportionate combination, and of the methods by which these truths were discovered and can be again demonstrated—these are the things which ought to be part of our common heritage and knowledge. I hope the next era will see, not the decay or the obliteration of the old traditions, but the addition of the new.

Thus to urge the claims of science as a valuable instrument of education of the kind necessary to train

our legislators and administrators is in no way to belittle other kinds of knowledge. As the Rector of the Imperial College of Science and Technology said in a recent address, "the scientific man is, after all, first a man and then a man of science, nothing which leaves out of sight his obligation to rule his life in accordance with the highest standards of health, of religion, and of morals, can fairly be called a good education." The student of science, then, must not ignore that great body of humanistic learning which has always been held in high esteem at our ancient universities. There is every reason why the man of science should be so far as practicable also a man of letters. Humanists and men of science alike must remember, indeed they are remembering, that culture is something broader and higher than mediæval schoolmen imagined. The scholar steeped in classical lore, yet ignorant of nature and her laws, is, we are beginning to realise, an uneducated pedant. The specialist in science, sublimely unconscious of the beauties of literature, and knowing nothing of the ideas of ancient and modern poets and philosophers, is a hopeless Philistine. How much the man of science may learn from the man of letters, and how beneficial to scientific work the influence exerted by literature may be, the Vice-Chancellor showed convincingly towards the end of his address.

I think no less that the man of science has much to learn from the man of letters. It has certainly been the case that the best men, or many of the best men, of science have been men full of the love and spirit of letters, keenly sensible of the beauty and attraction both of poetry and of prose. It was the case, as we all know, with Huxley and with Tyndall. It was so with Helmholtz, whose intellectual relation to Goethe is a most interesting episode. The fact is not so generally recognised, but it was the case with Darwin. It may seem a paradox to say that Darwin was a "man of letters," but I am almost prepared to maintain it. Too much has been made of the well-known passage in his autobiography in which he describes how he lost, through atrophy, his love for poetry, and not enough has been made of the warmth and the keenness of that love in his earlier days. He was a boy at Shrewsbury in the ultra-classical days of that very classical school, and was rebuked by Dr. Butler, the headmaster, who called him a "*pococurante*" because he worked at chemistry. But he tells us that he was very fond at school of the "Odes" of Horace; and when we find him, in that delightful book, the "Voyage of the *Beagle*," quoting in a few consecutive pages lines from the "Third Aeneid" of Virgil and from Shelley in the most natural and spontaneous manner, I think we may assert that his love of letters was lively and deep, and likely to have a permanent effect on himself. I have always thought some of the pages of the "Origin of Species"—for instance, the concluding pages—among the most poetical pieces of prose in the English language, and I think the secret of that style is to be found partly in the hereditary gift of his family, and partly in the early cultivation which it received. Again, few things are more fascinating to the thinker than the history of early Greek philosophy—those wonderful guesses (afterwards passed on to the Romans) with which the Greek thinkers anticipated in an intuitive and in exact manner the theories and demonstrations of later science. I would have the student of Dalton familiar with the guesses of Democritus and their repetition by Lucretius, and familiar, if possible, with them in their place in history. I would have the student of Aristotle read Darwin, and the student of Darwin read, as Huxley did, his Aristotle.

Dr. Warren's address, as we have said, may well fill men of science with hope as to the future of our old universities. It has often been our duty to point out in these columns how the nation has suffered from the erroneous ideas which have prevailed at Oxford and elsewhere as to the educational needs of students destined to become members of Parliament or civil servants in high places. Again and again insistence has been laid on the fact that the kind of education suited to the conditions of the days of the Renaissance is not in harmony with present-day needs. The work of men of science in the last hundred years has revolutionised life, but it is only now that it is beginning to be understood that the education given by our universities and by our schools of every grade must be adapted to present and coming needs.

Recent years have witnessed in many of our great provincial cities the growth of new universities fired with modern ideals; universities which look to the union of the scientific spirit with all that is best in humanistic learning to produce men cognisant of modern needs and conditions, and fitted to grapple with the difficulties inseparable from the administration of a great empire. The increasing competition among the great nations for pride of place, whether in industrial warfare, in intellectual rivalry, or in the contest to secure the most satisfactory social conditions, will be decided eventually in favour of the people most able to apply the methods and conclusions of science. In other words, that nation will prevail which succeeds in best educating at its places of higher learning the men in whose hands its destinies must be placed.

These truths are understood at our new universities, and modern requirements are shaping their regulations, their courses of work, and their general administration. Dr. Warren's address leads us to believe that the aims and objects of the new universities are appreciated at Oxford, and that it is intelligently and completely known by the university authorities that no slackening of effort and no fainting by the way must be permitted in the work which has been so successfully begun of making Oxford a great scientific university.

FIBRES FOR PAPER-MAKING.

THE Agricultural Department of the United States is investigating various fibrous waste materials with a view to their conversion into paper-makers' pulps or "half-stuffs." The *Times* of October 17 publishes a note giving some results of the experimental treatment of maize stalks, which are pronounced satisfactory.

The matter is of considerable importance. There exist a certain number of waste materials, such as megasse, cotton-seed hulls, flax and hemp straws of non-textile quality, which contain fibres useful for paper-making, and are available in concentrated areas in adequately large quantity to furnish "half-stuffs" in such volume as to be a serious factor in the determination of the world's supply, and therefore in controlling the ultimate cost of paper.

In considering these sources of supply, it is important to draw a sharp distinction between technical success and commercial success. All the above wastes have been, not once, but many times over, successfully worked up into papers of good quality. But for one reason or another the economic conditions for their industrial development have been lacking. A notable exception to this list of failures is the fibre of the cotton-seed hull. Within the last two years a definite industrial success has been recorded with this fibre, as the result of a treatment which is mainly mechanical. The fibre, purified from the adherent particles of shell, is now on the market under the name of "Virgo fibre."

Megasse, bamboo, and Para grass are being treated in Trinidad on practical lines; the half-stuffs and resulting papers are of remarkable quality, and the promises of industrial development are not unfavourable.